Running Characteristics of a Small Electric Vehicle Using a Fuel Cell Aided by EDLC

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Abstract

This paper proposes the introduction of a small and light-weight electric vehicle named Economy-Running EV with a single-passenger operating at minimum power. Driving power source in the trial electric vehicle using a fuel cell with a 24V, 200W is aided by EDLC (Electric Double Layer Capacitor) with capacity of 5F instead of a battery. At present, running characteristics of Economy-Running EV using a brushless dc motor as the drive system measures the current and voltage supplied to it, there are investigates the supplying electric energies and accelerating speed at starting. As a result, the supplying electric energies and accelerating speed are improved about 5 times and 2 times, respectively.

Keywords

electric vehicle, economy-running EV, fuel cell, metallic alloys for hydrogen storage, EDLC, brushless dc motor, environmental protection

1. INTRODUCTION

Recently, in the field of electric automobile, various models have already been produced by automobile industries and they will spread more and more as the regular vehicle of the environment conscious people in the future [Tamura et al, 2000; Yamaguchi et al, 2001]. However, there is no recognized standard for batteries or solar generators used in electric vehicles at present. Lithium-ion battery and fuel cell are adopted as power drive sources of electric vehicles at present [Yamaguchi et al, 2003].

We have previously proposed a small, light-weight and low power electric vehicle named Economy-Running EV with a single-passenger operating at minimum power. Driving electric source used in the trial electric vehicle was a fuel cell with a 24V, 200W aided by hydrogen storage material with the capacity of 500L filled-up to 1.5 MPa instead of a battery.

As the running characteristics of Economy-Running EV at the generating output power of fuel cell is 101W, the mileage when that is run at a speed of 23km/h using a filled-up fuel cell is about 62.5mile (100km). However, an accelerating speed at starting of trial electric vehicle has slowed caused by low output power and slow response of fuel cell compared with a battery [Yamaguchi et al, 2004].

Where, we have noticed to EDLC (Electric Double Layer Capacitor) based on characteristics as with a super capacity and possible the rapidly charge-discharge.

This paper has shown, an accelerating speed at starting of trial electric vehicle has improved, aided by EDLC with a capacity of 5F.

Running characteristics of trial electric vehicle aided by EDLC to fuel cell using a brushless dc motor as the drive system measures the current and voltage supplied to it, and investigates the supplying electric energy, accelerating speed at start and mileage when that is run at a specific speed using a filled-up fuel cell.

2. DRIVING SYSTEM

The block diagram of an Economy-Running EV using a fuel cell aided by EDLC instead of battery is shown in Figure 1.

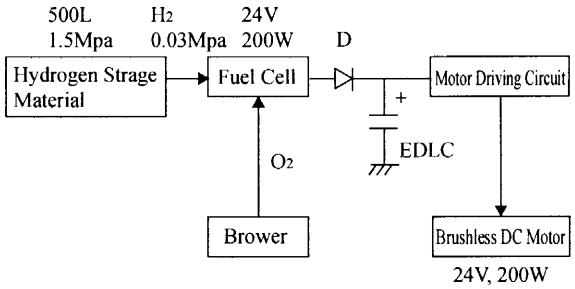


Fig. 1 Block diagram of a small electric vehicle using a fuel cell aided by EDLC

Driving electric source with a 24V, 200W is generated by a fuel cell. H_2 gas with the pressure of 15MPa is adjusted to 1.5MPa using a gas regulator, and H_2 gas is charged in the metallic alloys for hydrogen storage with a capacity of 500L for about 15 minutes. A blower of frequency control type rating 18V, 1A, 5000rpm is used to send O_2 in air into the fuel cell, the amount of air is

adjusted automatically corresponding to generated output. Gas pressure of H_2 send to fuel cell is adjusted to 0.03MPa. A driving motor is used as brushless dc motor rating 24V, 200W. A diode (D) of 25NC12 is used to protect the fuel cell against the reverse current from EDLC. Capacity and working voltage of used EDLC is 5F, 50V.

Generating voltage of fuel cell and supplying current to drive system include a brushless dc motor are monitored by using voltmeter and ampere meter of analog type.

3. GENERAL VIEW OF ECONOMY-|RUNNING EV

The front side view of constructed Economy-Running EV is shown in Figure 2. The body with weight of 18kg is constructed mostly using a carbon. The size of the body is 267cm x 71cm x 46cm. Metallic alloys for hydrogen storage is mounted on the rear side of the body. The Economy-Running EV is constructed having two front wheels and a single rear wheel using a rear wheel-drive. There is a built-in fuel cell in the rear side of the body.

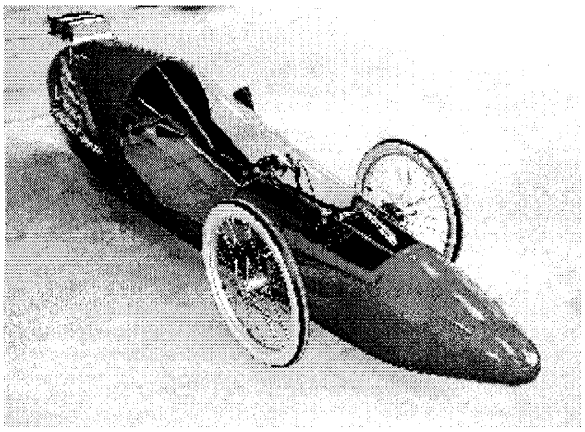


Fig. 2 General view of economy-running EV

4. GENERAL VIEW OF EDLC

An accelerating speed at starting of trial electric vehicle has slowed caused by low output power and slow response of fuel cell compared with a battery.

Recently, an EDLC is mostly used to hybrid car aided by motor to engine, it is based on electric characteristics as with a super capacity and possible the rapidly charge-discharge. Where, we have noticed to EDLC in order to improving an accelerating speed at starting. Figure 3 showed the EDLC mounted on the acryl board. The capacity 5F/50V EDLC set on acryl board consists of 20 series, each with the capacity of 100F with the working voltage of 2.5V. A diode of 25NC12 is mounted on a fin of radiator, and it showed the down below of right side in Figure 3.

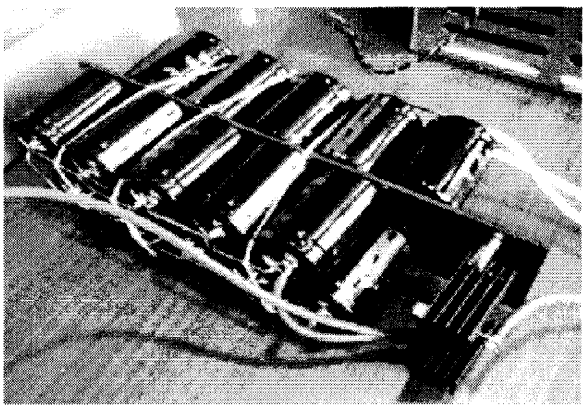
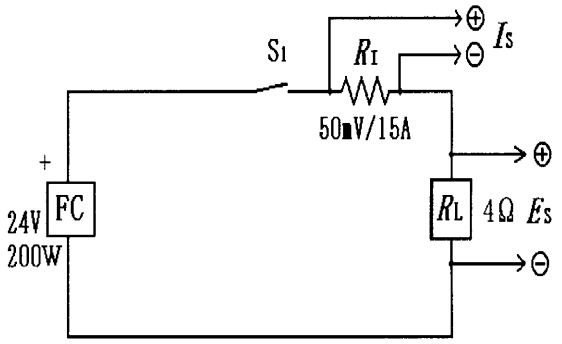


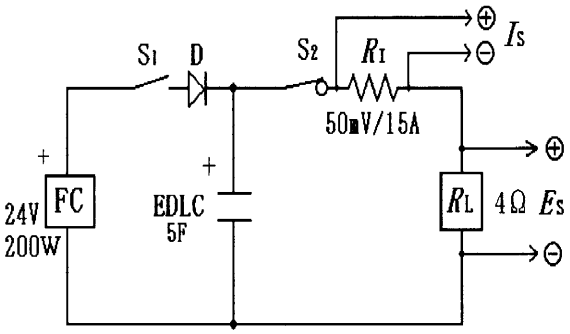
Fig. 3 Appearance of EDLC with capacity of 5F

5. CHARACTERISTICS OF SUPPLYING ELECTRIC ENERGIES FOR DRIVING SYSTEM

Supplying electric energies into driving system including dc motor are investigated in cases of FC and (FC+EDLC) using a resistor of 4Ω corresponding to electric power of 101W based on the speed of 23km/h. Measuring circuits of supplying electric power $Ps=EsIs$ for FC only and (FC+EDLC) are shown in Fig.4(a),(b). Measurement of supplying current Is is done by a terminal voltage of current sensitive resistor with a value of 50mV/15A that is installed between the fuel cell and RL = 4Ω. The terminal voltage is measured using a



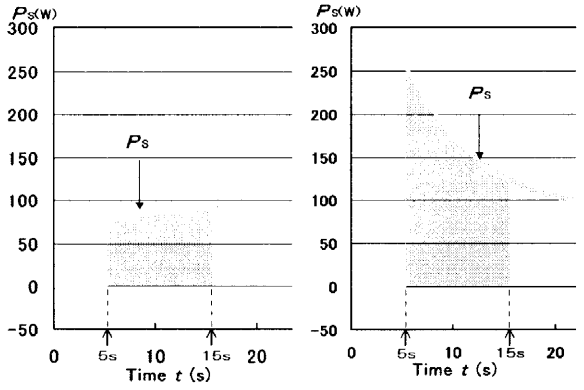
(a) FC only



(b) (FC+EDLC)

Fig. 4 Measuring circuits of supplying electric power Ps for FC only and (FC+EDLC)

Memory Hi-Corder. In case of FC only in Figure 4 (a), measuring switch of Memory Hi-Corder is closed (ON) at $t = 0$. Next, switch S_1 is closed to after 5s, Es and Is are measured. In case of (FC +EDLC) in Figure 4 (b), switch S_2 is closed firstly as shown in figure and initial charge of EDLC is discharged to zero. Then, switch S_2 is opened (OFF) and EDLC is charged passing the diode (D) until generating voltage of fuel cell by closing the switch S_1. Further, switch S_2 is closed at after the 3 minutes, the times is corresponding to $t = 5$s in Figure 5 (b), and Es and Is are measured.



(a) FC only (b) (FC+EDLC)

Fig. 5 Comparison of supplying electric energies Ws for FC only and (FC+EDLC)

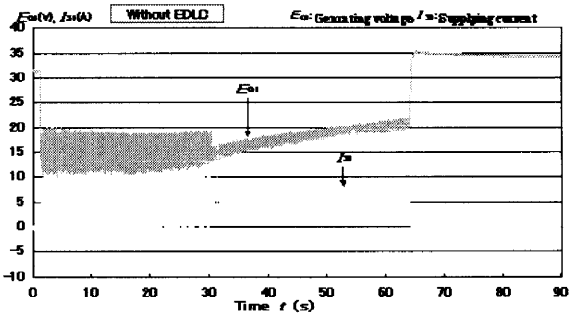
The characteristics of supplying electric energies Ws corresponding to the section of time between $t = 5$ -15s are shown in Figure 5 (a), (b). Supplying electric energies $Ws = Ps\ t$ for FC only and (FC+EDLC) are 10.6Ws and 19.6Ws, respectively. Supplying electric energies in case of using (FC+EDLC) is improved about 2 times comparing with that of FC only.

6. RUNNING CHARACTERISTICS OF ECONOMY-|RUNNING EV

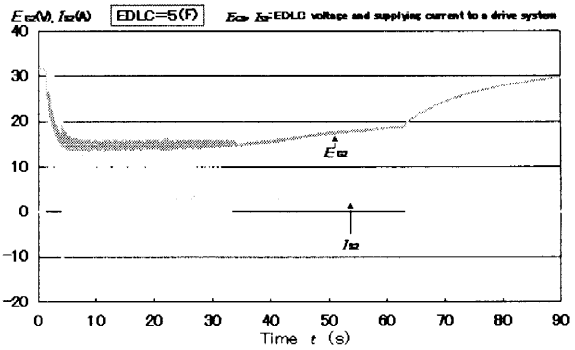
The terminal voltage corresponding to generating voltage E_G and supplying current Is are supplied to Memory Hi-Corder while the Economy-Running EV is running, and the data obtained is downloaded to flash card. Then, the data of flash card are processed by using a personal computer, and their characteristics are printed.

6.1 Characteristics of supplying current and generating voltage while running

Characteristics of generating voltage EG and supplying current Is while running a mileage of about 0.13mile (210m) on flat ground is shown in Figure 6. Measuring switch of Memory Hi-Corder is closed (ON) at $t = 0$ and Economy-Running EV is started at $t = 2$s. Measuring circuits of E_G and Is for FC only and (FC+EDLC) are used as driving system including a brushless dc motor instead of $R_L = 4\Omega$ shown in Figure 4 (a), (b). Variable resistor corresponding to accelerator is set at maximum at the same time of the start. In case of FC only shown in Figure 6 (a), $t = 32$s after the start, dc motor is operated to nearly steady state. Output power (E_{G1} Is_1) of dc motor is decreased corresponding to the time proceeds, speed of Economy-Running EV is increased. The output power is 101W (21V x 4.8A) while covering the distance of 210m at a maximum speed of 24km/h. In case of (FC+EDLC) shown in Figure 6 (b), supplying current Is_2 to dc motor of $t = 2$s after the start is about 25A corresponding to about 6 times comparing with Is_1 = 4A of FC only. That is, EDLC with capacity of 5F



(a) FC only



(b) (FC+EDLC)

Fig. 6 Running characteristics for FC only and (FC +EDLC)

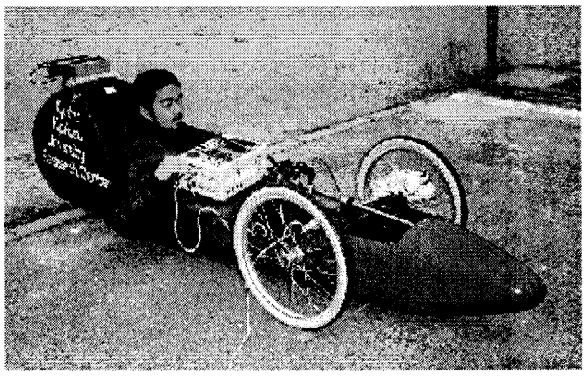
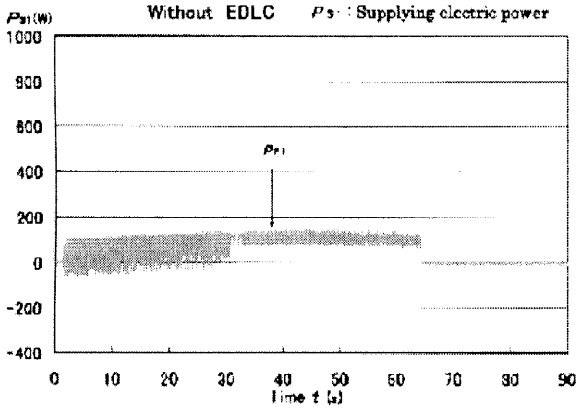


Fig. 7 Measurement view of running characteristics

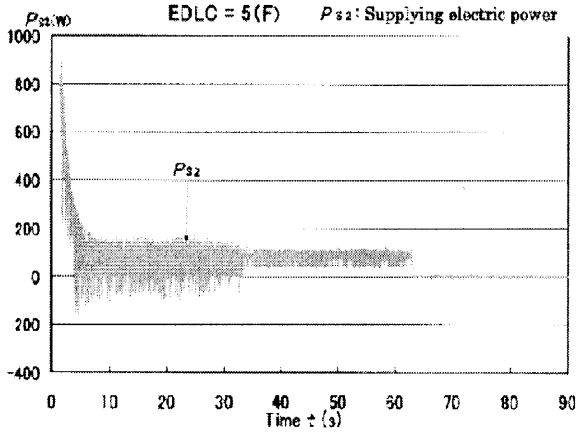
contributes to the accelerating speed at start. Further, t = 34s after the start, dc motor is operated to nearly steady state. The output power is 83W (18.9V x 4.4A) while covering the distance of 210m at a maximum speed of 23km/h. Measurement view of running characteristics is showed in Figure 7. Memory Hi-Corder is set on body of driver.

6.2 Characteristics of supplying electric power while running

Characteristics of supplying electric power Ps while running are obtained by using the E_G and Is of running characteristics measured. Supplying electric power $Ps_1 = E_{G1}Is_1$ in case of FC only is shown in Figure 8 (a). Supplying electric power $Ps_2 = E_{G2}Is_2$ in case of (FC+EDLC) is shown in Figure 8 (b). Supplying electric power Ps_2 of t = 2s after the start is about 800W corresponding to about 16 times compared with Ps_1 = 50W of FC only. That is, Supplying electric energies Ws_2 of t = 8s after the start is improved about 1.98kWs corresponding to about 5 times comparing with Ws_1 = 400Ws of FC only.



(a) FC only



(b) (FC+EDLC)

Fig. 8 Supplying electric power of running characteristics for FC only and (FC+EDLC)

6.3 Characteristics of accelerating speed at starting

Measurement of running speed is carried out by counting the digital signal generated in proportion to the number of rotations of a tire. Digital signal is obtained by on-off of lead switch operating the magnetic field of magnet set on the spokes of the right front wheel. Variable resistor corresponding to accelerator is set at maximum at the same time of the start.

Characteristics of accelerating speed at starting for FC only (without EDLC) and (FC+EDLC) while running a mileage of about 210m on flat ground are shown in Figure 9. The EDLC are used the capacity of 1F and 5F. Accelerating speeds at t = 8s after the start for without EDLC, EDLC = 1F and EDLC = 5F are about 4.5km/h, 6.5km/h and 9km/h, respectively.

Therefore, accelerating speed at t = 8s after the start for EDLC = 5F is improved about twice as comparing with the without EDLC.

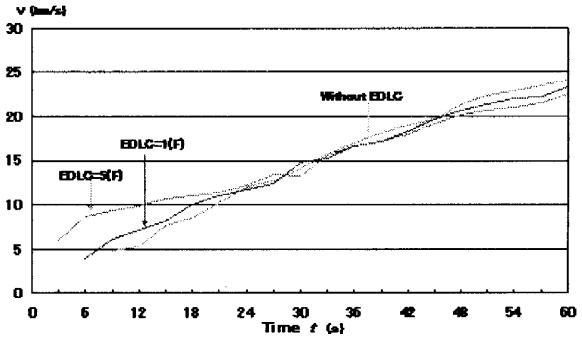


Fig. 9 Characteristics of accelerating speed at starting

7. CONCLUSION

This paper has proposed the introduction of a small and light-weight electric vehicle named Economy- Running EV with a single-passenger operating at minimum power. Driving power source in the trial electric vehicle using a fuel cell with a 24V, 200W by use of a metallic alloys for hydrogen storage filled-up to 1.5MPa is aided by EDLC with capacity of 5F instead of battery.

As a result, we have obtained the following.

(1) Supplying electric energies at t = 8s after the start for EDLC = 5F is improved about 5 times comparing with the without EDLC.

(2) Accelerating speed at t = 8s after the start for EDLC = 5F is improved about twice comparing with the without EDLC.

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